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NOISE LEVELS NEAR STREETS, EFFECTIVENESS AND COST ABATEMENT MEASURES

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16. Abstract During the years 1975-1978, the Experimental Institute for Heat and Sound Technology of the Technologisches Gewerbemuseum in Vienna under contract with the Federal Ministry for Construction and Technology carried out research concerning the current noise levels near streets, the annoyance felt by the population, possible noise abatement measures for these streets, and the economic impact of such measures. A detailed report in four parts has been prepared. In the following we give a brief summary.

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TECHNICAL CONFERENCE OF THE ÖAL 1978 NOISE ABATEMENT TODAY AND TOMORROW:

NOISE LEVELS NEAR STREETS, EFFECTIVENESS AND COSTS OF NOISE ABATEMENT MEASURES

Judith Lang*

During the years 1975 - 1978, the Experimental Institute for Heat and Sound Technology of the Technologisches Gewerbemuseum in Vienna under contract with the Federal Ministry for Construction and Technology carried out research concerning the current noise abatement measures for these streets, and the economic impact of such measures. A detailed report in four parts has been prepared. In the following we give a brief summary. /156**

ANNOYANCE OF THE POPULATION

After a pilot study of the annoyance of the population due to traffic noise in the city of Vienna in 1963 and 1964 [1] and a very extensive study including an evaluation of responses by 2640 persons (60 measuring locations) in Vienna between 1973 and 1974 [2], we have in the current study questioned 462 persons at 49 measuring locations in the 5 Austrian States, partly in rural, and partly in city quarters. The continuous equivalent noise level (A-valued) was between 47 and 75 dB.

Table 1 shows the results for the question, to what extent the respondents are content with their living conditions and also the reasons for any discontent. Included are the answers of the group that felt "very content" to the question "Is there anything at your location with which you are not quite as content?"

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** Numbers in margins indicate foreign pagination.

TABLE 1. DEGREE OF SATISFACTION WITH LIVING CONDITIONS

Satisfaction with living conditions					
Very content 1	Reasonably Content 2	More or less content 3	Not content 4	Very unsatisfied 5	Average
41%	17%	27%	8%	6%	2.22

Among reasons were mentioned:

	Traffic noise	Other noise from outside	Noise from neighbors	Other negative environmental factors	Not enough greenery	Other short-comings	Other answers	No answer
in the case of not complete satisfaction	67%	6%	4%	25%	1%	32%	9%	2%
in the case of very content persons as answer to the question "Is there anything..."	30%	3%	2%	11%	-	7%	32%	28%

Among the 462 respondents a total of 52% mentioned immediately traffic noise as an impairment of their living quarters; and additional 8% stated in response to a specific question that either they themselves or a member of the family are disturbed by traffic noise. If we combine the results of the questioning with the noise level, measured in $L_{eq}(A)$, in the living quarter, we find a clear correlation of the annoyance with the traffic noise; however, the correlation is different from that found for the inner-city traffic noise in Vienna. Among possible reasons are the different type of streets within cities and in rural areas (mostly interstate highways), the different type of housing (in the rural areas one-family houses with gardens), the different degrees of habituation (the streets are mostly newer in the rural areas), or the different noise level due to the quarter itself (in the rural areas), or the different noise level due to the quarter itself (in the rural areas with their smaller population density this level is lower). Figure 1 shows the results in relation to the type of housing. We conclude that limiting values found for inner-city traffic noise cannot be simply taken over for new streets in rural quarters.

BASIS FOR THE COMPUTATION OF NOISE LEVELS DUE TO STREET TRAFFIC

The basis for the computation of equivalent continuous noise levels due to street traffic in Austria is currently contained in ÖAL Richtlinie 23 and ÖNORM S 5021. We compare this basis with that of other countries and the results of numerous measurements and propose a very slightly different method. We compute the equivalent continuous noise level L_{eq} (A) of streets without houses from the number n of vehicles per hour:

$$L_{eq}(A) = 32 + 10 \lg n + \Delta_{LKW} + \Delta_{ST} + \Delta_{LN} + \Delta_{V} + \Delta_{E} + \Delta_{W}$$

Percentage of heavy vehicles among the total vehicle number (rounded to %)	Correction (dB)
	Δ_{LkW}
0 - 10 %	0
11 - 20 %	+2
21 - 30	+3
31 - 40 %	+4
41 - 50 %	+4
51% above	+5
Street surface	Δ_{ST}
Black top, not ribbed	0
Concrete, speed over 70 km/h	+3
Ribbed black top	+5
Stone paving	+8
Inclination (rounded to%)	Δ_{LN}
< 3 %	0
3 - 4 %	+ 2
5 - 6 %	+ 3
7% and above	+ 4
Main traffic speed	Δ_{V}
below 70 km/h	0
70-100 km/h	+4
above 100 km/h with trucks, 0-10%	+7
11-20%	+5
above 21%	+4
Length of the effective street section	Δ_{W}) sem.
Distance from the street center line	Δ_{E}) Diagr

NOISE ABATEMENT MEASURES

In terms of noise abatement measures one may consider architectural measures with respect to the streets and, for some street sections, traffic restrictions. Among the latter are speed limits (which lead to 5 - 8 dB noise reduction in the case of strict enforcement); there is also the possibility to reduce the percentage of heavy vehicles (which may result in a noise reduction of 3 or 4 dB, depending on the percentages). Reference [3] contains a discussion of traffic control measures.

Architectural measures consist essentially in screening the traffic lanes from the objects to be protected, either by constructing the street above or below level, or by building walls and protective mounds.

Diagrams [4] are available for the construction of screening devices. These diagrams are useful in dimensioning noise abatement measures. It is found that the length of the screens is crucial and that a certain noise reduction can be obtained by various combinations of height and length. In dimensioning a screen one best determines first the desired noise reduction and then the various length/height combinations and the total resulting screen surface; one then chooses the combination with the minimum cost, usually the combination with the minimum surface. If the optimum surface for different values of noise reduction is plotted, one is able to predict the cost increase for a given increase in noise reduction, that is, what amount of noise reduction can be obtained with a given economic input.

Aside from geometrical factors, sound absorption data are of importance for the resulting noise reduction. The amount of sound passing through the wall should not exceed the amount diffracted at the upper edge of the wall. Since most screening walls do not reduce noise by more than 15 dB due to limited lengths, and since a stronger reduction appears unnecessary on

the basis of existing traffic noise levels and limiting values, the walls should have at least a reduction measure of 25 dB.

Theoretical computations and scale measurements show that, depending on the geometrical conditions, sound absorptive measures on the wall are able to reduce the noise level. Sound absorbing walls are especially required, if the screening is on both sides of the street, or if the wall is opposite to a reflecting surface, such as a warehouse, or a natural cliff. They also are needed, if they reflect sound into areas that are supposed to be protected.

We have collected a list of altogether 60 types available in Austria, the FRG, and Switzerland, with a description of the construction and the degree of sound absorption as a function of frequency. In particular, we quote the sound-transmission characteristics and the quantities $\Delta L_{A \ll Str}$ and $\Delta L_{A \ll B}$. The latter two quantities describe the absorption. They state the reduction of sound from 100% reflection for street noise (Index Str) to the level of A-valued residual reflection; index B gives the same data for rail traffic noise. We have investigated the objective sound reduction by a protective wall as well as the subjective evaluation for two examples.

ECONOMIC FACTORS

It is generally assumed that noise abatement measures on streets cost money; it is indeed possible to compute accurately the costs in a given case. By contrast, the annoyance of the population by noise is difficult to express in monetary terms, if not impossible. One then obtains the impression that the benefit cannot be expressed in quantitative form. Similarly, there is no data base available to compare different measures in the form, for instance, of a cost-benefit analysis. We have tried for this reason to collect data on the economic importance of

noise abatement and the definition and weighting of the aims. Here, use may be made of the costs incurred by noise-annoyed persons, or the amount of money these persons are willing to spend. Among the 462 persons we have interrogated, 28% have already undertaken noise abatement measures, 10% have used technical means; the costs were in the range between 200 and more than 10,000 shillings. Another 5% contemplates technical measures. The stated costs were normalized to the total number of interrogated persons in the various areas with their different noise levels; they are shown in Figure 2. Also quoted are expenses connected with a contemplated move. One could use these figures as benefit for noise abatement measures in the form of the "willingness-to-pay" method. It should be noted, however, that these expenses refer to measures that do not alter the noise disturbance itself: Insulating windows requires them to be closed which in turn means that the rooms are not in better use. In fact, the change in the use of rooms reduces the value of the house or apartment.

Another important source of data is the difference in price of houses and apartments with and without noise annoyance. For this purpose, we included a question in our interrogations, and we also checked with 83 real estate specialists. The results are summarized in Table 2.

The difference in price or value is an expense due to noise, at least in the cases where the owners want to sell their property.

We have suggested criteria and purpose functions for studies of the type of cost-benefit analyses. In the case, where a "minimum of annoyance of the persons living near the street due to traffic noise" is the purpose, we have used the number of annoyed persons resulting from the equivalent continuous noise level (in steps 5 dB) computed for a street with a given projected

TABLE 2. VALUE OR PRICE DIFFERENCE AMONG REAL ESTATE OBJECTS WITH OR WITHOUT TRAFFIC NOISE

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	Percentage value or price differential between objects with and without traffic noise		
Average given by 83 real estate specialists	Main artery	-35%	when compared with location at residential street
	Highway with entrance or exit	-10%	
	Highway without	-30%	
	Planned street with high traffic volume	-20%	
Average from 379 questioned persons	Quiet neighborhood	+22%	by comparison with location on street with strong traffic noise.
Statements by 72 persons living under condition of strong traffic noise in Vienna	-5% to more than -20%		due to traffic noise

vehicle count per hour. From this figure we obtain the expected percentage of annoyed persons according to Figure 1 and the total number of persons living in the various zones with their equivalent continuous noise levels.

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Percentage of annoyed persons

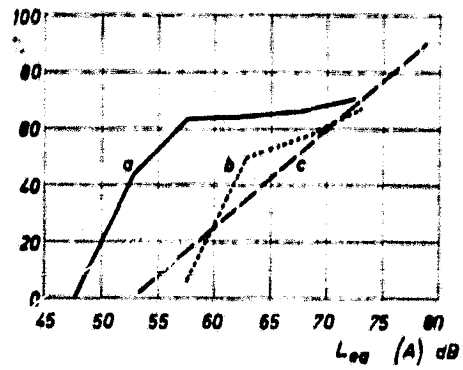
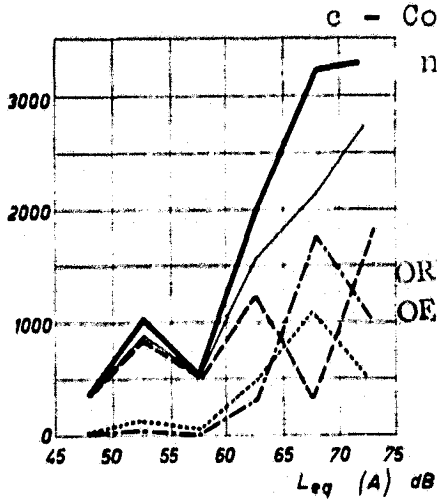


Figure 1. Annoyance due to traffic noise as a function of type of housing

a - persons with a balcony, a terrace or a garden (392 individuals)

b - Other questioned persons (total 70)

c - Comparison result in Vienna (inner-city traffic noise)



----- Already spent

-.-.-. Planned to spend

____ Sum of --- and -.-.-

..... Expenses for moving

____ Total

Figure 2. Expenses the population is willing to incur for noise abatement in their houses and apartments.